Verification of time accuracy of geomagnetic recording

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I. Introduction

Up to now, geomagnetic observatories provide users with one minute data in most cases. The timekeeping of observatory data loggers should be better than 5 s per month to be accepted by INTERMAGNET. Such a requirement was approved before the beginning of the GPS era.

At present, many observatories provide one second data or are going to provide them in the nearest future . Several years ago INTERMAGNET has carried out a survey of the scientific and observatory community on this issue. From this survey it turned out that a timing accuracy of 0.01sec is required in this case, so that a GPS or equivalent timing method must be used.

The challenge addressed in this study is to check whether observatory data fulfill the above requirement. The presented method is a proposal how to measure the time accuracy of one second data.

II. Which factors influence the time accuracy of geomagnetic recordings?

The most important factors than can influence the time accuracy of geomagnetic recordings are:

- Time accuracy of used digital data logger,
- Kind of digital data processing, e.g. digital filtration applied during calculation of one second data,
- Parameters of analog filter used in variation magnetometer (for example, an analog 3-sec-filter delays the signal by about 1 s).

III. The main assumptions for the measurement method

The main conditions which should be taken into consideration when designing a measurement method are the following:

- Result of measurement should concern to whole recording system from sensors to output data (e.g. IAGA 2002 files), to make more precise we don't examine only digital data logger used in data acquisition system,
- The reference for such an investigation are pulses generated by means of a GPS receiver. It is not a difficult problem to obtain such pulses with an absolute accuracy order of 1 msec,
- Time markers (pulse markers) concerning the moment of changing minutes should be identifiable in a special way (for example longer signal). The time markers areindispensable for time calibration of the auxiliary digital data logger. That's why the time accuracy of auxiliary data logger can be adjusted with an accuracy order of 1 msec. So the original time accuracy of auxiliary data logger has no effect on the result of measurement of time accuracy.
- The examination of time accuracy is carried out for several sinusoidal calibration signals: e.g. 0.2 Hz. 0.1 Hz, and 0.05 Hz.

The block diagram of the measurement method is shown in Fig.1.

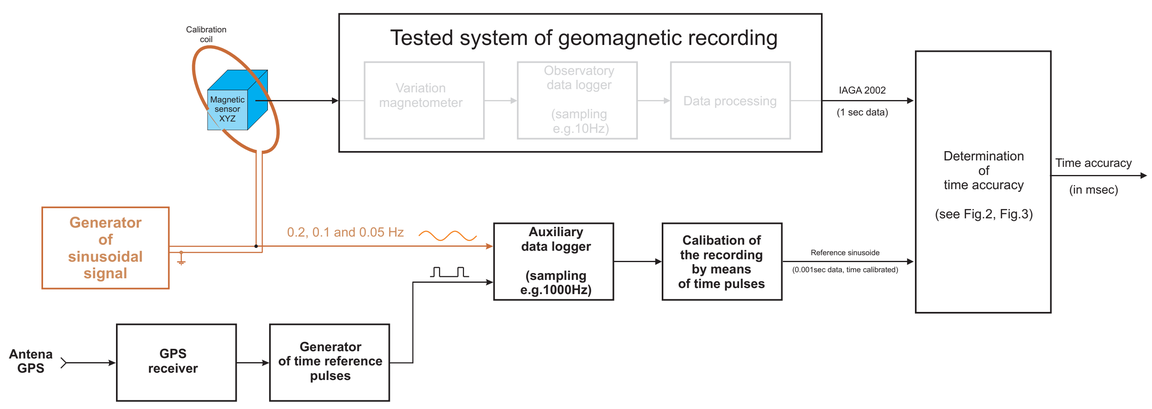

Fig.1. Block diagram of measurement method

IV. Determination of time accuracy

First, the data from auxiliary data logger must be calibrated in time domain by means of reference pulses obtained by a GPS receiver. Then the time-domain calibrated data from the auxiliary data logger are converted to 1 sec data. This conversion should not shift data in time.

Next, both the data from tested system (IAGA 2002) and 1 sec. data from auxiliary system are digitally filtered. It is a band-pass filtration, the frequency of this filter is the same as the frequency of the sinusoidal generator. Similarly as before, this operation should not shift data in time.

This preparation of both signals for comparison in time domain is depicted in Fig.2.

Finally, both series of 1 sec data are compared in time domain. In order to carry out such a comparison we should determine the parameters of both sinusoids. These parameters we calculate by means of regression analysis. This stage is illustrated in Fig.3.

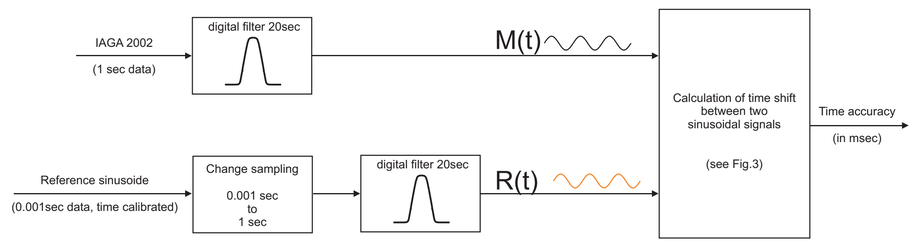

Fig.2. Preparation of signals for determination of shift between tested and reference signals.

$$M(t) \quad A_m \sin 2 f ((t \quad t_m) \quad _m) \qquad R(t) \quad A_r \sin 2 f ((t \quad t_r) \quad _r)$$

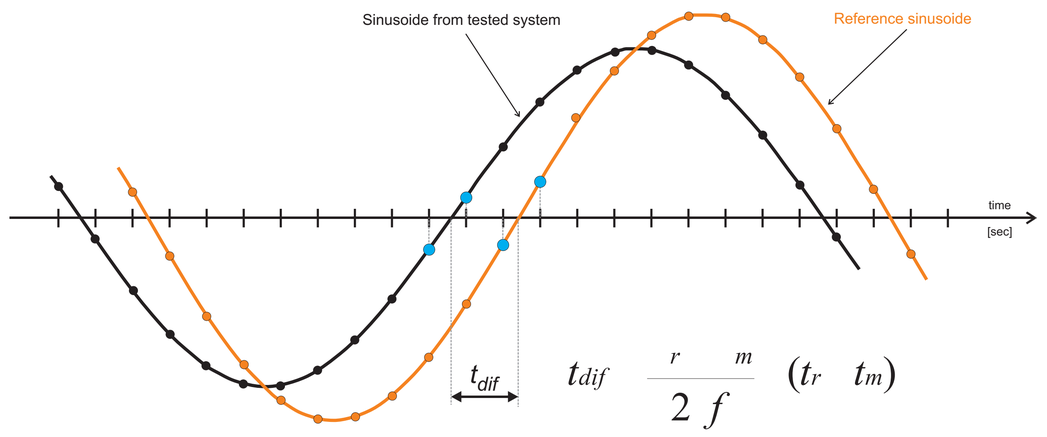

Fig.3. Determination of time shift t_{dif} between tested system and reference sinusoide

All measurements

Period [sec]	$_r - _m$ [deg]	t_{dif} [msec]
5	11.7249	162.846
10	5.89282	163.689
20	2.93336	162.964

After delete 5% the worst measurements

Period [sec]	$_r - _m$ [deg]	t_{dif} [msec]
5	11.7248	162.844
10	5.87943	163.318
20	2.93451	163.028

Table.1 .Protocol of mesurements of time shift t_{dif} between tested system and reference sinusoide

V. Summary

The presented method makes it possible to determine the time accuracy of geomagnetic recordings with an accuracy order of 1 msec. So this method allows to check whether a tested recording system for geomagnetic data fulfills the accuracy of 10 msec. which is required by INTERMAGNET for 1 sec data.

References:

St-Louis B.J. (editor), 2007, INTERMAGNET Technical Reference Manual, version 4.3, 88pp.

Love, J.J., 2006, 1-Second Operational Standard for Intermagnet, private communication.